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Abstract

This experimental study investigates two bargaining games with two-sided incomplete information between a seller and a buyer. In the first game with no outside options many subjects do not use the incomplete information to their advantage as predicted. We find that a model with adjusting priors better explains observed behavior. The second game gives the buyer the option to buy via search or return to bargaining. Here many buyers choose a bargaining agreement when a search outcome is predicted. For those who opt out, search outcomes are overall efficient and behavior is relatively close to the optimal search policy.

Keywords: Bargaining Experiment, Outside Option, Search
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Forthcoming in Games and Economic Behavior

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1 Introduction

Suppose a buyer meets a seller who offers to sell him a particular item he has been looking for. They start to bargain over the price, each of them uncertain about the other's valuation for the item. While the seller currently has no other potential clients, the buyer can quit negotiations and search for better alternatives, but he can also return to the seller at any time. Information and outside options are two crucial strategic factors in a bargaining setting. This paper investigates how they influence bargaining behavior in an experiment.

The extensive literature on bargaining experiments has brought substantial insight into people's motivation, in particular, when observed behavior departs from the theoretical prediction. Starting with Güth et al. (1982), many ultimatum games experiments showed that most subjects prefer "fair", i.e. more equitable outcomes to the extreme predictions. Bargainers are concerned not only with their own monetary payoff when they evaluate bargaining outcomes, but they may be willing to give up some of their profit in order to attain a more symmetric outcome, or to punish the partner for being greedy. More recent models of preferences consider these experimental results that are not in line with standard theory predictions.[1] Gantner et al. (2001) find that subjects differ in equity types when various equity standards are applicable. Experiments on alternating-offers bargaining (e.g., Hoffman and Spitzer 1982, 1985) show that "fair" allocations are observed when players are randomly assigned their roles; when positions are earned in a preliminary game, however, the winning player receives a larger payoff, and asymmetric payoffs seem to be more acceptable. When a fixed *outside option* is introduced, the experiments by Binmore et al. (1989, 1998) showed that this makes the threat of ending negotiations credible, and earnings increase for the player who has the outside option. When the outside option is high, but still smaller than the size of the bargaining cake, the proportion of conflicts increases. In the presence of *incomplete information*, experimental results also tend towards more competitive bargaining: In a simultaneous-demand bargaining experiment by Hoggatt et al. (1978), only about one quarter of all agreements are equal splits; subjects learned to avoid low initial demands over time. Kuon (1994) finds that in a bargaining experiment with incomplete information about the opponent's outside option, subjects bargain more competitively with higher outside option values and with increasing experience. Weak players (those with a low outside option) pretend to be strong.

We want to test how well theory predicts the allocation of the gains from trade to the "right" player in the presence of incomplete information, when a strong payoff asymmetry is implied by the rules of the game. In other words, if the rules

[1] See e.g. the contributions of Bolton and Ockenfels (2000), Charness and Rabin (2000), and Fehr and Schmidt (1999).

leave little room for social preferences but rather support strategic behavior, does standard theory then offer good predictions for bargaining outcomes, or are there alternative behavioral rules that can better explain observed behavior?

For this purpose, we take the Chatterjee and Samuelson (1987) model of alternating-offers bargaining with two-sided incomplete information, which is a major contribution to the theory of bargaining with incomplete information. When offers are restricted, the model predicts a unique equilibrium in which the first mover may use the incomplete information to conceal his type and thus receive a larger share of the total surplus.[2] In an extension of this bargaining setting, Gantner (2008) adds an outside option for the buyer, modeled as a sequential search process with non-negotiable prices. The theoretical analysis shows that despite the option to switch between the bargaining and search process repeatedly, a bargaining agreement may be achieved without delay, and an agent who starts search will never return to bargaining when both agents know the value of search. These two models shall be tested in an experiment to answer some simple questions about subjects' behavior in a more complex bargaining environment: Do they use the incomplete information to their advantage? When do they bargain and when search? The search option supports a more selfish bargaining behavior, but at the same time the possibility of choosing a bargaining agreement with benefits for both players over a risky search outcome in which the partner is left with empty hands may affect behavior.

Two previous experiments that allow for an uncertain outside option in a bargaining setting are Zwick and Lee (1999) and Carpenter and McAndrew (2003). Both models differ in their setup and prediction from our model. They use a complete information bargaining setting, in which search consists of a single random draw, while in our model agents can hide behind the incomplete information, the buyer can move between the bargaining and search process anytime, and search is not limited. Zwick and Lee allow only for one-shot bargaining, and they test two regimes: one with recall of the seller's initial price after the realization of a search offer and one without recall. In the latter, agents are committed to pay the price for the search offer once they chose to opt out, which is not the case in our setup. In the former, two types of equilibria are characterized: depending on the search cost, they find an equilibrium with and one without search. Carpenter and McAndrew (2003) allow for exactly one renegotiation, which follows ultimatum bargaining rules. The agent with the outside option can choose between search and an immediate counteroffer. The subgame perfect equilibrium implies that the outside option is never taken, since the renegotiation yields a higher return, thus

[2]The asymmetry in the gains from trade is also maintained when the restriction of the offer set is relaxed, as shown in a subsequent study by Chatterjee and Samuelson (1988). Despite the existence of multiple equilibria in this model, there is only one equilibrium with plausible beliefs, and it has the same features as the unique equilibrium in the restricted offers model.

search is not relevant for the equilibrium outcome. They find that initial offers are similar to those of ultimatum games, but many fair offers were rejected, and agents search when it would have been better to make a counteroffer. They respond conciliatory when returning to bargaining, but make more aggressive counteroffers if they do not opt out. Note that in our model we have a potentially infinite bargaining horizon where bargaining rules do not change, thus our bargaining setting is different from these models, furthermore the calculation of the reservation price is cognitively more demanding in our infinite-horizon search, thus our equilibrium strategies are more complex.

A third paper with a setup comparable to ours is the reputation model by Lee, Weg and Zwick (2005), in which sellers in a repeated game are incompletely informed about buyers' cost of an outside option to search for a better price, modeled as a random draw from a uniform distribution. The difference to our model with respect to search is that buyers are committed to pay the price from search once they decided to opt out, i.e. there is no recall of the bargaining offer. But we can learn something about strategic reputation building during bargaining: While the theoretical prediction of their reputation model entails Bayesian updating by sellers and reputation building by buyers, none of it is found in the experimental data. Sellers ask too low prices immediately, thus buyers are "deprived " of the opportunity to build up a reputation. The authors conclude that at best one can observe that people are slow in achieving the reputation they desire. They suggest that the ultimatum nature and the complexity of the outside option overwhelm a reputation behavior that would be more in line with theory. The results of our game without outside option seem to confirm their conclusions, since many sellers do not try to conceal their type, however, introducing an outside option for buyers results in bargaining prices higher than expected, even though the ultimatum nature of the game remains for the seller. We think that subjects' beliefs that diverge from those of the predictions in these games may give a better explanation for the observed deviations, and we test a model in which subjects adjust these beliefs according to their individual experience in section 4.2 and 4.4.

Since search behavior is an important part of our study, two major findings from the experimental literature on sequential search shall be pointed out. One is that search is highly efficient in terms of earnings (Schotter and Braunstein 1981, Hey 1987, Kogut 1990, Sonnemans 1998). The other finding is that subjects tend to search too little compared to the optimal rule (Cox and Oaxaca 1989, Schotter and Braunstein 1981). This may point towards risk-averse behavior: subjects prefer an offer located from search over the "lottery" of continuing search that yields a better expected outcome. In a series of experiments, Cox and Oaxaca (1989, 1992, 2000) provide a systematic exploration of theoretical predictions of finite search models. They find that a model assuming risk averse behavior performs well in the experimental test.

The rest of the paper is organized as follows: Section 2 theoretically describes the two models of the bargaining games with and without outside option. Section 3 describes the three treatments that were tested in the experiment, section 4 reports the experimental results and section 5 concludes.

2 Two Bargaining Models

In this experiment we investigate two games. *Game 1* is a bargaining game between a seller and a buyer with two-sided incomplete information and restricted offers. *Game 2* has an additional outside option, which is to search for a better price. The two games are presented in detail in the following subsections.

2.1 Bargaining without Outside Option

Game 1 is a restricted-offers bargaining game with two-sided incomplete information as analyzed by Chatterjee and Samuelson (1987). Seller S and buyer B bargain over the price p of an indivisible good. They are imperfectly informed about each other's valuation for the good. Each agent can be one of two possible types: B's valuation (BV) can be either high or low: $BV \in \{HV, LV\}$; similarly, S's cost (SC) can be either high or low: $SC \in \{HC, LC\}$. Let $LC \leq LV < HC \leq HV$. At time 0, B's prior belief that he faces a low-cost S is π_S^0, and S's prior belief that he faces a high-value B is π_B^0. The priors are exogenously given and are common knowledge. Agents update their beliefs according to Bayes' rule. Price offers p are restricted to a high-price offer $p_h = HC$ and a low-price offer $p_l = LV$. Let t denote the bargaining period. Bargaining between B and S proceeds as follows: In $t = 1$, S makes an offer, and B responds with one of three choices: he can accept S's offer, or reject and make a counteroffer, or quit. If B accepts or quits, the game is over. If B makes a counteroffer, agents enter $t = 2$, in which S decides whether to accept B's offer, or reject and make a counteroffer, or quit. If S accepts or quits, the game is over. If S makes a counteroffer, it is B's turn in $t = 2$. There are no exogenous restrictions on the length of bargaining, but a discount factor $\delta < 1$ is applied to future payoffs. The payoffs are $p - SC$ for S and $BV - p$ for B in case of trade, otherwise they are zero.

It is clear from the setup of the model that the only acceptable price for a high-cost S is p_h and for a low-value B it is p_l, otherwise these agents would make losses; they shall thus be called inflexible agents. Mutually beneficial trade between two inflexible types is not possible. On the other hand, a high-value B and a low-cost S can accept either offer without making losses; they shall thus be called flexible agents. Flexible agents may have a strategic incentive to conceal their type in order to make higher profits.

As Chatterjee and Samuelson (1987) show, bargaining proceeds only for a finite but endogenously determined number of periods. An equilibrium in which both flexible agents reveal their type in $t = 1$ exists if demanding p_l and thus receiving $LV - LC$ in round 1 is better for S than demanding p_h, when B will accept p_h in round 1 with probability π_B^0, and with probability $1 - \pi_B^0$ the game continues to the next round:

$$\pi_B^0(p_h - LC) + \delta(1 - \pi_B^0)(p_l - LC) \leq p_l - LC \tag{1}$$

which gives the boundary value for π_B^0:

$$\pi_B^0 \leq \frac{(p_l - LC)(1 - \delta)}{p_h - LC - \delta(p_l - LC)} \equiv \bar{\pi}_B. \tag{2}$$

In this case, a buyer will infer from an offer of p_h that he faces an inflexible S. Then a flexible B accepts p_h; an inflexible B quits.

An equilibrium in which a flexible S conceals his type, i.e. he offers p_h, thus only exists if his belief that B is flexible is sufficiently high ($\pi_B^0 > \bar{\pi}_B$). Then B will reveal his type before S if

$$\delta\pi_S^0(HV - p_l) + \delta(1 - \pi_S^0)(HV - p_h) \leq HV - p_h \tag{3}$$

that is, if B's prior that S is flexible is sufficiently low:

$$\pi_S \leq \frac{(HV - p_h)(1 - \delta)}{\delta(p_h - p_l)} \equiv \bar{\pi}_S. \tag{4}$$

Since delay is costly, this would happen in round 1. Then the best response for a flexible S is to accept p_l in $t = 2$, since S must conclude that he faces an inflexible buyer if he is offered the low price in round 1 when $\pi_S \leq \bar{\pi}_S$.

If neither condition (2) nor (4) are satisfied, the equilibrium is in mixed strategies.[3] As Chatterjee and Samuelson show, this game has a unique sequential equilibrium:

Proposition 1. *The bargaining game with two-sided incomplete information (Game 1) has a unique Nash equilibrium in which a flexible S offers p_l in $t = 1$ if $\pi_B^0 \leq \bar{\pi}_B$. A flexible B accepts p_h in $t = 1$ if $\pi_B^0 > \bar{\pi}_B$ and $\pi_S \leq \bar{\pi}_S$. If none of the conditions hold, the equilibrium is in mixed strategies.*

[3] As the parameters of the experiment will be chosen such that there exists an equilibrium in pure strategies, we shall not go into details of the mixed strategy equilibrium.

2.2 Bargaining with Search as Outside Option

In *Game 2*, bargaining process, information about the types and parameters are as described in *Game 1*. The only difference is that instead of quitting, B can now choose to opt out and buy via search. Figure 1 shows the move-structure of the bargaining-search game. During the search phase, B receives a non-negotiable offer each period. Upon receipt, he can accept this offer, or reject and continue search, or renegotiate with S. For simplicity, we consider a discrete-time model in which outside offers y are random draws from a discrete uniform distribution on the interval $[0, \bar{y}]$, where $\bar{y} \in \mathbb{N}$. B and S have identical information about the distribution of the outside offers.

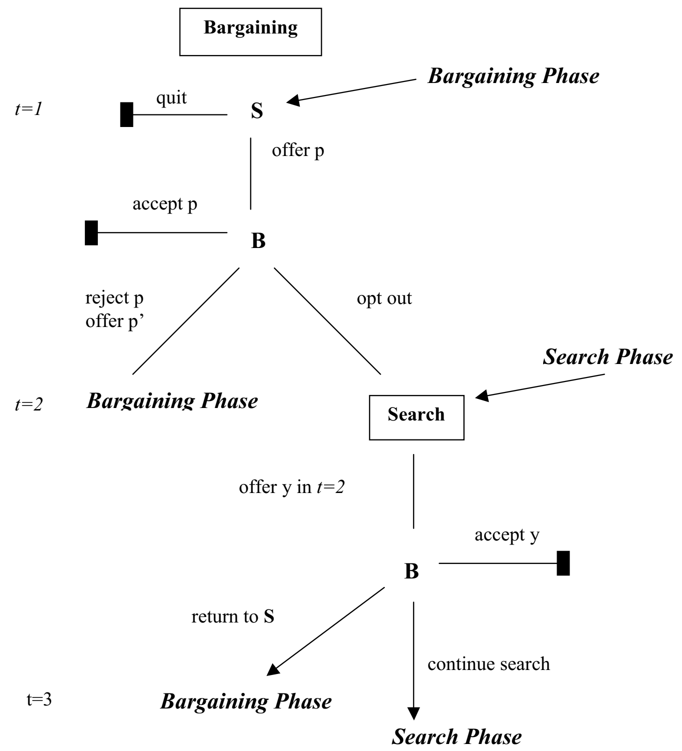

Figure 1: The Bargaining and Search Game

To find the equilibrium strategies for this bargaining and search game, we need to know how good the search option is compared to the bargaining alternative. The value of search is determined by the optimal reservation price y^*, which is the price at which B is just indifferent between continuing search for one more period and accepting the current search offer. This reservation price depends on B's valuation V. B is said to follow the reservation price policy if he rejects all outside offers $y > y^*$ and accepts any $y \leq y^*$. Since we have a discrete uniform distribution of outside offers, y^* is the solution to:

$$V - y^* = \delta \left[\frac{1}{\bar{y}+1} \sum_{y=0}^{y^*} (V - y) + \frac{\bar{y} - y^*}{\bar{y}+1} (V - y^*) \right] \tag{5}$$

Gantner (2008) describes the equilibrium of this game with a continuous-time search process in which verifiable outside offers come from a Poisson distribution. The analysis is adapted to the simpler setting of the present game, in which exactly one outside offer drawn from a discrete uniform distribution is available in each period of search, and furthermore B loses the outside offer if he decides to return to S. Since the reservation price is increasing in the valuation, there is no separation of types in which only the inflexible B would bargain. We thus confine our attention to the flexible buyer's reservation price y^*_{HV}, as it drives the bargaining results. The bargaining-search equilibrium of this game is characterized by the following proposition:

Proposition 2. *In the bargaining-search game with two-sided incomplete information and symmetric information about the outside option, the flexible B opts out in $t = 1$ and follows the reservation price policy if $y^*_{HV} < p_l$. If $y^*_{HV} \geq p_l$, then two flexible agents agree on p_l in $t = 1$ if at least one of the following conditions holds: (i) $y^*_{HV} \leq p_h$; (ii) $\pi^0_B \leq \bar{\pi}_B$. If neither condition holds, then two flexible agents agree on p_h in $t = 1$ if $\pi^0_S \leq \bar{\pi}_S$. Otherwise, there is no equilibrium in pure strategies.*

Condition (i) thus identifies a "good" outside option for B, and it gives the flexible S the incentive to reveal his type. Condition (ii) is already known from the pure bargaining game. Since it is known at time zero whether the conditions stated in Proposition 2 are met, and future payoffs are discounted, a flexible S will reveal his type immediately if (i) or (ii) are satisfied. It thus follows that B only starts search with the intention to accept an offer from search, but never to induce S to lower his offer.

Corollary 1. *On the equilibrium path of the bargaining-search game with symmetric information about the outside option, the buyer never returns to bargaining.*

The proofs are omitted since they are direct applications of Gantner's (2008) model. For an experimental test of the described models, we can thus identify some clear predictions. In *Game 1* the obvious question is whether the high surplus is assigned to the "right" player. If parameters are chosen such that S has a strategic advantage in *Game 1*, we would expect to see this advantage vanish in *Game 2* when search parameters for B are chosen appropriately. We can thus test whether games in *Game 2* end in the bargaining or search phase as predicted, how long agents search and whether they return to bargaining.

3 Experimental Setup

3.1 Treatments

Three treatments (NOO, GOO, BOO) were designed to test the predictions of the models described above. The theoretical predictions described for each treatment rely on the standard assumptions that agents care only about their own monetary payoff and that they are risk-neutral.

Treatment NOO ("No Outside Option") refers to *Game 1*. The seller cost is either $LC = 3$ or $HC = 22$ with equal probability. The buyer value is either $HV = 37$ or $LV = 18$ with equal probability. Offers are restricted to a high price offer $p_h = 23$ or a low price offer $p_l = 17$.[4] Future payoffs are discounted by a factor of $\delta = 0.8$ for each bargaining period. When two flexible agents are matched, the theoretical prediction assigns the high surplus to the seller according to Proposition 1: $\pi_B^0 = .5$ exceeds the critical value $\overline{\pi}_B^0 = .32$ calculated from (2), thus a flexible S should conceal his type in $t = 1$. At the same time, B's belief $\pi_S^0 = 0.5$ is below the critical value $\overline{\pi}_S^0 = 0.83$ calculated from (4), thus a flexible B should immediately accept p_h. The respective column in Table 1 summarizes the theoretical predictions for all possible pairs of agents in this treatment.

Pair	Treatment NOO	Treatment GOO	Treatment BOO
LC-HV	**agree** on p_h in t=1	**search** for $y \leq 16.1$	**agree** on p_l in t=1
	S gets 20, B gets 14	S gets 0, B gets 20.9	S gets 14, B gets 20
LC-LV	**agree** on p_l in t=2	**search** for $y \leq 9.9$	**search** for $y \leq 12.1$
	S gets 11.2, B gets 0.8	S gets 0, B gets 8.1	S gets 0, B gets 5.9
HC-HV	**agree** on p_h in t=1	**search** for $y \leq 16.1$	**search** for $y \leq 20.3$
	S gets 1, B gets 14	S gets 0, B gets 20.9	S gets 0, B gets 16.7
HC-LV	**disagree** (quit)	**search** for $y \leq 9.9$	**search** for $y \leq 12.1$
	S gets 0, B gets 0	S gets 0, B gets 8.1	S gets 0, B gets 5.9

Table 1: Theoretical Predictions for all Treatments

In treatments GOO ("Good Outside Option") and BOO ("Bad Outside Option") subjects played the bargaining-search game *(Game 2)* with varying quality of the search option. An offer from search was a random draw from a discrete uniform distribution with support $\{0, 0.1, 0.2, ..., \bar{y} - 0.1, \bar{y}\}$. In GOO we set $\bar{y} = 25$, while

[4] In the Chatterjee-Samuelson (1987) model, offers come from the set {LV, HC }, i.e., the low-value B (high-cost S) gets zero from accepting the low (high) price, and he also gets zero from quitting. In order to avoid the situation of indifference between these two payoffs, we deviate from the original model and let the offers be $\{LV - \epsilon, HC + \epsilon\}$, where we set $\epsilon = 1$. This does not affect the theoretical solution of the original model.

in BOO $\bar{y} = 50$, thus BOO had the worse outside option. All parameters of the bargaining process were identical with those of NOO. The reservation prices for the two types of B can be calculated from (5). In GOO, we have $y^*_{HV} = 16.1$ and $y^*_{LV} = 9.9$ and thus, according to Proposition 2, all games should end in the search phase since the reservation prices are below p_l; Table 1 lists the predictions for all possible matches in this treatment. Note that the payoffs from search are in expected terms. For BOO, reservation prices are $y^*_{HV} = 20.3$ and $y^*_{LV} = 12.1$. Since $p_l < y^*_{HV} < p_h$, Proposition 2 predicts that a low-cost S reveals his type in $t = 1$. A high-value B accepts if offered p_l and searches if offered p_h. A low-value B always searches since $y^*_{LV} < p_l$. The last column in Table 1 lists the predictions for all possible pairs in this treatment.

3.2 Experimental Procedure

The experiment was conducted at the University of California, Santa Barbara (USA) in 2002 and at Simon Fraser University (Canada) in 2003 using the software *z-tree* (Fischbacher 2007).

Subjects. A total of 144 participants were recruited amongst undergraduate students of any major. Each subject participated in one treatment only.

Treatments. Each of the three treatments was tested in 4 sessions and 48 subjects per treatment. A session consisted of 20 rounds[5] of the respective treatment with an unrestricted number of periods. While their role as a buyer or seller was fixed throughout the session, subjects played different types of their role, i.e. at the start of each round a random draw decided whether a subject was a flexible or inflexible type in the current round.[6]

Instructions and Matching. Play was anonymous via computers, and subjects were informed that their bargaining partners would change in each round, but there was some chance that they might face the same partner more than once.[7] Subjects were given written instructions for both roles as buyer and seller, and they played two practice rounds in order to become familiar with the basic rules of the game and the computer interface.[8] At each stage of the game the computer screen displayed the period, the subject's own cost or valuation, his available choices (including the current offer from bargaining or search) and the (discounted) profit in case of acceptance of the current offer. In GOO and BOO sellers were informed when their

[5]There were two exceptions: one session had 12 rounds and one had only 10 rounds.

[6]By experiencing the change in their own type, the given prior probabilities of 0.5 for each type should be more credible.

[7]Each matching group consisted of 3 buyers and 3 sellers, thus a subject played the same partner more than once, but never in two subsequent rounds. Additionally, since each player's type was randomly drawn for each new round, chances were high that at least one player's type was different from the last time they played each other.

[8]The complete set of instructions can be found in the appendix.

partner was searching. At the end of each round, subjects were informed about their profits in the round.

Payoffs. Each subject received a show-up fee of $7. Additionally, two rounds were drawn at random at the end of each session and subjects were paid off the profits they made in these two rounds at a rate of 1:1. The average payoff was $22, each session lasted for at most 2 hours.

4 Experimental Results

4.1 Bargaining: Descriptive Results

We shall start by looking at outcomes. Later on, we will investigate how they emerged by investigating subjects' strategies more closely. In the following, we use the pooled data from the two experimental locations; we did not find significant differences in first-period decisions between the two locations for all types of agents.

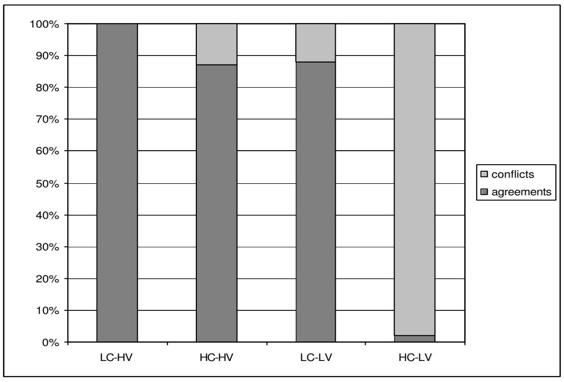

Figure 2: Agreements and Conflicts in Treatment `NOO`

Agreements: Figure 2 shows the distribution of agreements and conflicts for `NOO`. All pairs in which two flexible types were matched (LC-HV), and thus a total surplus of 34 was available, reached an agreement. When a flexible and an inflexible type were matched, we find agreements in 88% for LC-LV and in 87% for HC-HV pairs. The maximal total surplus available for these pairs is 15, assigning a profit of 1 to the inflexible agent. Theory predicts an agreement for all three types of pairs, however, in the experimental data the proportion of agreements in these pairs are significantly different (χ^2, $Pr < 0.005$). If only LC-LV and HC-HV pairs are compared, i.e. pairs in which the size of the total surplus is identical, the proportion of agreements are not significantly different. We thus conclude that, in contrast to the theoretical prediction, agreements are not independent of the size of the bargaining surplus. Finally, we find 2% agreements in all pairs in which two inflexible types were matched (HC-LV), i.e. where mutually beneficial trade was not possible. This is not significantly different from the predicted rate of zero.

Surplus allocation: When two flexible agents are matched (LC-HV), standard theory predicts S to receive the high surplus $s = 20$ in period 1, B thus gets the low surplus $s = 14$. Figure 3 displays the observed surplus allocations for all pairs. In LC-HV pairs we find that B, i.e. the "wrong" player, gets the high surplus in 59%. This certainly does not support the theoretical prediction of the surplus allocation. The Wilcoxon matched-pairs signed-ranks test cannot reject the null hypothesis that B and S make the same profits in LC-HV pairs (mean profits are 16.07 for S and 17.08 for B). The two-sided sign test rejects the null of equality of medians at a 10% level.

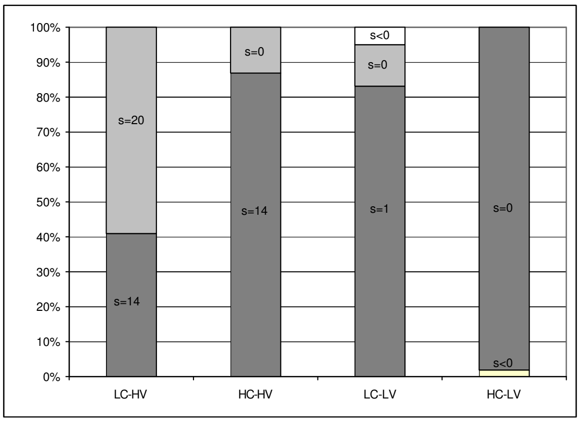

Figure 3: Buyers' Surplus in Treatment `NOO`

For pairs in which a flexible and an inflexible agent are matched (HC-HV and LC-LV), the predicted outcome assigns $s = 14$ to the flexible and $s = 1$ to the inflexible agent. It is the only possible agreement in which no agent makes losses. The distribution of allocations here matches the theoretical prediction in over 80% in both types of pairs. However, even though all agents can make some positive profit through an agreement, we find breakdowns ($s = 0$) in about 12% in both types of pairs. 5% of buyers in LC-LV pairs make losses ($s < 0$), while no losses are observed in HC-HV.

Bargaining length: For flexible agents a trade-off exists between reaching an early agreement and hiding information. Figure 4 considers only agreements whose surplus allocation is consistent with the theoretical prediction and shows how many of these occurred in the "right" period. For 88% of LC-HV pairs in which the flexible S received the high surplus, the game ended in period 1 as predicted. This looks convincing regarding the accuracy of theory prediction, however, as already seen, the predicted *allocation* was only observed in 40% of LC-HV pairs.

For LC-LV pairs, Figure 4 shows that only about 50% achieve an agreement in $t = 2$ as predicted, while about 40% find an agreement already in $t = 1$. The latter implies that sellers offered the low price immediately. For HC-HV pairs, 80% of the agreements that correspond to the predicted outcome occur in period 1 as predicted. This implies that these buyers immediately accepted the high price.

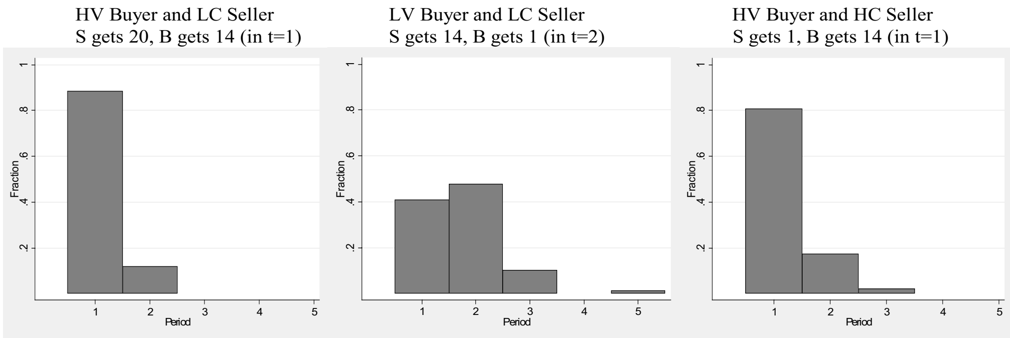

Figure 4: Predicted Allocations and Time in Treatment `NOO`

Table 2 displays the proportion of all agreements that were achieved within the first two periods. 83% of all agreements between two flexible agents occurred in period 1, and by period 2 all pairs have reached agreements. For HC-HV pairs, we find that 81% of all agreements occurred in period 1. In LC-LV pairs, the rate of immediate agreements is still 39% when none are expected from the theoretical prediction in $t = 1$. Overall, the timing pattern shows that most agreements were reached by period 2, independent of the surplus allocation. As for LV-HC pairs, where no agreement is expected, the prediction regarding the timing of a disagreement is not very strong, as agents should just choose between a payoff of zero now or zero later. In fact, there is a considerable number of subjects still bargaining after period 3, thus giving the bargaining partner a repeated chance to come to an agreement. The Mann-Whitney test corroborates the hypothesis that HC-LV pairs bargain significantly longer than all other pairs ($Pr < 0.001$).

Table 2: Time of Agreements in Treatment `NOO`

Pair	# agreements	in $t = 1$	in $t \leq 2$
LC-HV	104	91 (0.83)	104 (1.00)
HC-HV	104	84 (0.81)	102 (0.98)
LC-LV	93	36 (0.39)	83 (0.89)

Behavior and Learning: Overall, the observations regarding surplus allocation and timing indicate two things: First, subjects seem to have well understood that delay is costly when gains from trade exist. Second, a significant proportion

Table 3: Initial Offers in Treatment `NOO`

Type		**high price**	**low price**
LC sellers	offer	0.54	0.46
HC sellers	offer	0.99	0.01
HV buyers	accept	0.71	1.0
	reject	0.29	0
	quit	0	0
LV buyers	accept	0	0.82
	reject	0.86	0.11
	quit	0.14	0.07

of low-cost sellers did not conceal their type in an attempt to get the high surplus as predicted. Table 3 shows that only 54% of all low-cost sellers ask p_h in period 1. What needs to be checked in order to better understand these deviations is whether buyers behaved as predicted. Table 3 shows that 71% of HV buyers immediately accepted p_h if the seller offered it. This corresponds to an expected acceptance of a high price in about 35% for all buyers, when 50% were predicted. Why do not more sellers attempt to get the high surplus? And why do not all HV buyers accept p_h? The design of this experiment does not leave much room for social preferences due to the strong asymmetry in payoffs; it rather encourages strategic behavior. For example, the only way to avoid an asymmetric outcome is to quit, thus a preference for symmetric payoffs is very costly when two flexible players are paired. We do not observe any disagreement in LC-HV pairs and conclude therefrom that subjects do not choose to avoid asymmetric payoffs when own forgone profits are relatively high. When a flexible and an inflexible player are paired, a disagreement implies a forgone profit of at most 1 for the inflexible player, while the opponent's foregone profit is 14. In this case, it is mostly the inflexible player who initiates the disagreement, however, we observe only 12% of disagreements, thus there is no strong evidence for deviations from the prediction because players in the weaker position want to punish the opponent for being greedy.

Given that the data shows some significant deviations from the prediction which assumes profit-maximization and risk-neutrality, we shall check whether alternative behavioral assumptions can better explain observed behavior. One such alternative would be *risk-aversion.* If we consider the expected return for a LC seller from offering p_h and p_l in treatment `NOO` using the data of the experiment, we find that mean profits are 13.2 with p_h as initial offer and 13.7 with p_l, while standard deviations are 5.9 and 2.5, respectively. It turns out that offering p_h is simply more risky while offering the same expected profit as p_l. Furthermore, the bargaining game of treatment `NOO` allows agents to quit the game, which adds an ultimatum flavor to the game. While being a theoretically empty threat, an experiment by

Weg and Zwick (1994) showed that such an outside option of zero value has a significant attenuating effect on the demand of the strong player.[9] Thus, there are two sources of risk: the risk of delay, and the risk of a breakdown, both of which are costly. The deviation of sellers' behavior from the prediction could thus be attributed to the increased risk of the high price strategy. But this explanation is not entirely consistent with observed behavior in the treatments with search. If risk-aversion were the only explanation for a behavior that diverges from predictions, we should certainly expect that LC sellers immediately reveal their type in `GOO` and `BOO`, since the outside option gives even more bargaining power to the buyer. However, as will be shown, many LC sellers offer p_h, therefore a key to understand behavior may be in the expectations they had when they made their initial offers.

It is possible that subjects in the role of a seller only learn with *experience* that they have a strategic advantage. In this case, behavior may converge over time towards the theory prediction. Interesting dynamics regarding this behavior are revealed in Table 4, where agents' behavior over the course of the 20 rounds is displayed for treatment `NOO`. The 20 rounds were divided into 3 blocks consisting of rounds 1-7, 8-13 and 14-20. In the early block, a proportion of 0.62 of LC sellers offer p_h, this decreases significantly to 0.44 in the late block (χ^2-test, $Pr < 0.05$). The direction of change is thus opposite of what would be expected if subjects' behavior converged to the theory prediction. This raises the question whether the change in sellers' behavior is an adjustment in response to an initially unexpected buyers' behavior. If a sufficient number of buyers is expected to reject p_h, it becomes optimal for LC sellers to ask p_l immediately. HV buyers' behavior from Table 4 shows that the rejection rate of p_h first increases, then decreases considerably. What can explain this behavior? To answer this question, we also need to take into account strategies on an individual level, where we find that 25% of all sellers always offer p_h in $t = 1$, while 12% never offer p_h in all rounds where they act as LC sellers. We thus have about 37% of sellers who stick to their initially chosen strategy, and almost two thirds of all sellers who change their initial offer over time when they have low cost, and thus cause the variation as seen in Table 4. This change in behavior over time points towards an adjustment process. We follow the idea from the reputation experiment of Camerer and Weigelt (1988) that some agents may have a "homemade belief", i.e. even if they were not induced to do so, subjects may act as if some opponents of a certain type behave like another type. Strictly speaking, our use of "homemade beliefs" refers only to the opponent's behavior in the next step, however, given that over 95% of all rounds where gains from trade are possible ended by $t = 2$, these beliefs are a good characterization of subjects' beliefs about the outcome of the round. We assume that the beliefs are updated according to individual experience. If LC sellers assume that more than

[9] We are grateful to an anonymous referee who pointed out this result.

the critical proportion ($1 - \bar{\pi}_B = 0.68$) of all buyers will reject p_h, i.e. if 36% of the HV buyers also reject p_h in addition to all LV buyers, the best response is then to offer p_l immediately. Now in the middle block, we find that 44% of HV buyers reject p_h, which is sufficient to make p_l the optimal initial offer. Thus, updating their priors, more LC sellers will offer p_l in the following rounds. The response in later rounds is corresponding: fewer LC sellers offer p_h than in the early block.

Table 4: Flexible Agents' behavior over Time in `NOO`

Block	LC offers p_h	HV rejects p_h	S accepts p_l in t=2
1	54/87 (0.62)	15/62 (0.24)	32/76 (0.42)
2	33/64 (0.52)	25/60 (0.42)	9/67 (0.13)
3	26/59 (0.44)	9/49 (0.18)	9/46 (0.19)
Total	113/210 (.54)	49/171 (0.29)	50/189 (0.26)

But why do HV buyers even increase their rejection rate of p_h in the middle block? Consider what buyers may learn from their rejection of p_h for future rounds, which is displayed in the fourth column of Table 4: 42% of all sellers whose high price has been rejected in $t = 1$ accept in $t = 2$. This is a lesson for both buyers and sellers: buyers are affirmed in their rejection of p_h, thus more HV buyers will reject p_h in the 2nd block, and more LC sellers decrease their initial high price offers in expectation of a rejection. However, this development does not continue, as now in the middle block less sellers (13%) accept the low price in $t = 2$ (χ^2, $Pr < 0.01$). This signals to HV buyers that there is less to gain in rejecting p_h: Thus, in the 3rd block, the rejection rate decreases to 18%, and a similar proportion of all sellers are willing to change their initial offer in $t = 2$. This adjustment process shall be formalized in an econometric model, and different behavioral types of subjects shall be defined and tested for in the next subsection.

4.2 Econometric results of `NOO`

In this section we perform a maximum likelihood error-rate analysis of subjects' decisions following the general lines of the econometric model used in Costa-Gomes et al. (2001). Our econometric model is a mixture model in which each subject's type is drawn from a common prior distribution over three types. Let $i = 1, ..., N$ index the subjects, let $k = 1, 2, 3$ index our types. The three types are briefly described as follows:

Sellers: A LC seller of type 1 (prediction) offers p_h and accepts p_l in $t = 2$. A LC seller of type 2 (risk averse) immediately offers p_l. HC sellers of both types always offer p_h. Type 3 (adjusting) plays a best response according to the past experience, which shall be explained in more detail below.

Buyers: A HV buyer of type 1 (prediction) accepts all offers. A HV buyer of type 2 (risk loving) accepts p_l and rejects p_h in $t = 1$, in $t = 2$ he accepts all offers. LV buyers of both types accept p_l and reject p_h. Type 3 (adjusting) plays a best response according to the past experience.

We assume that a type-k subject normally makes a type-k decision, but in each period makes an error. We first describe the behavior of types 1 and 2, which does not change with the rounds played. Let A_t be the set of actions available in period t. In each period, types 1 and 2 make an error with probability $\varepsilon_k \in [0, 1]$, in which case they choose each of their m_t decisions $a_t \in A_t$ with probability $\frac{1}{m_t}$. The probability of a type-k decision for $k = 1, 2$ is then $1 - \frac{m_t - 1}{m_t}\varepsilon_k$ and the probability of any single non-type-k decision is $\frac{1}{m_t}\varepsilon_k$. We assume errors are independently and identically distributed across games, periods and subjects. Then the probability to observe a strategy (a_1, a_2) in round r given that individual i behaves as a type-k agent ($k = 1, 2$) with cost c ($c \in \{HC, LC\}$ for sellers and $c \in \{HV, LV\}$ for buyers) is given by:

$$P_{c,r}^{i,k}(a_1, a_2) = \begin{cases} \left(1 - \frac{m_1-1}{m_1}\varepsilon_k\right)\left(1 - \frac{m_2-1}{m_2}\varepsilon_k\right) & \text{if type-k decisions in } t = 1 \text{ and } t = 2 \\ \left(1 - \frac{m_1-1}{m_1}\varepsilon_k\right)\frac{1}{m_2}\varepsilon_k & \text{if type-k decision in } t = 1 \text{ and not in } t = 2 \\ \frac{1}{m_1}\varepsilon_k\left(1 - \frac{m_2-1}{m_2}\varepsilon_k\right) & \text{if type-k decision in } t = 2 \text{ and not in } t = 1 \\ \frac{1}{m_1}\varepsilon_k\frac{1}{m_2}\varepsilon_k & \text{if no type-k decisions in } t = 1 \text{ and } t = 2 \end{cases} \tag{6}$$

Note that if a subject behaves as type 1 or 2, the game must have ended by $t = 2$ if at least one flexible agent is involved. If the game has ended already in $t = 1$, the probability to observe action a_1 in round r given that individual i behaves as a type-k agent is given by:

$$P_{c,r}^{i,k}(a_1) = \begin{cases} 1 - \frac{m_1-1}{m_1}\varepsilon_k & \text{if type-k decision in } t = 1 \\ \frac{1}{m_1}\varepsilon_k & \text{if no type-k decision in } t = 1 \end{cases} \tag{7}$$

While this specification completely describes the behavior of types 1 and 2, type 3's behavior is more complex. We assume that this adjusting type has some prior beliefs that may diverge from those given by the experimenter. He updates these "homemade" beliefs according to his individual experience and then chooses the best response of all available actions. To model this behavior, we use a standard logistic discrete choice specification, which incorporates possible errors via the precision parameter of the logistic model and where the errors are sensitive to payoff differences.[10] Due to the potentially infinite time horizon of the game, we needed to impose a restriction in order to have a finite strategy space. Since over 95% of all games involving a flexible agent ended by $t = 2$, we considered the complete action space for 2 periods a sufficiently large subset to describe the relevant strategy space for this type. A seller with cost c can offer p_l or p_h in $t = 1$ and then choose between accept, reject and quit in $t = 2$, thus he has 6 possible strategies available. A buyer with value c may accept, quit, or reject in $t = 1$ conditional on the seller's offer, and in the case of rejection he chooses again between these 3 actions in $t = 2$ and thus has 10 strategies for the first two periods. In each of the 20 rounds, agents update their beliefs about the opponent's response using the past observations.

In round r, the probability to observe strategy (a_1^*, a_2^*) given that individual i behaves as a type-3 subject with cost c is given by:

$$P_{c,r}^{i,3}\left(a_1^*, a_2^*\right) = \frac{e^{\lambda_1 E_{c,r}^i\left(a_1^*, a_2^*\right)}}{\sum\limits_{a_1 \in A_1, a_2 \in A_2} e^{\lambda_1 E_{c,r}^i\left(a_1, a_2\right)}} \tag{8}$$

where $\lambda_1 \in [0, \infty]$ is a precision parameter and $E_{c,r}^i\left(a_1, a_2\right)$ is the expected value of strategy (a_1, a_2) in round r for an agent characterized by cost c. Correspondingly, if the game ended after $t = 1$, the probability to observe action a_1 in round r given that individual i behaves as a type-3 subject is given by:

$$P_{c,r}^{i,3}\left(a_1^*\right) = \frac{\sum\limits_{a_2 \in A_2} e^{\lambda_1 E_{c,r}^i\left(a_1^*, a_2\right)}}{\sum\limits_{a_1 \in A_1, a_2 \in A_2} e^{\lambda_1 E_{c,r}^i\left(a_1, a_2\right)}} \tag{9}$$

.

We now describe by way of example all possible expected values $E_{c,r}^i(a_1, a_2)$ for an individual i in the role of a seller who offers p_h in detail, all other cases are calculated analogously:[11]

$$\begin{aligned}
E_{c,r}^i\left(p_h, acc\right) &= (p_h - c) \cdot \beta_r^i(acc|p_h) \\
&\quad +0.8 \cdot (p_l - c) \cdot \left(1 - \beta_r^i(acc|p_h) - \beta_r^i(quit|p_h)\right) && (10)\\
E_{c,r}^i\left(p_h, rej\right) &= (p_h - c) \cdot \beta_r^i(acc|p_h) \\
&\quad +\mu_{c,r}^i(p_h, rej) \cdot \left(1 - \beta_r^i(acc|p_h) - \beta_r^i(quit|p_h)\right) && (11)\\
E_{c,r}^i\left(p_h, quit\right) &= (p_h - c) \cdot \beta_r^i(acc|p_h) && (12)
\end{aligned}$$

where $\beta_r^i(b_1|p_h)$ denotes i's subjective probability that the buyer responds with $b_1 \in \{acc, rej, quit\}$ when i offers p_h in $t = 1$ of round r, and $\mu_{c,r}^i(p_h, rej)$ denotes

[10] We thank an anonymous referee for suggesting this specification.

[11] A detailed description of these cases as well as all further estimation results are available from the authors upon request.

seller i's expected continuation payoff in round r deriving from his rejection in $t = 2$ of the buyer's counteroffer, given that the initial offer was p_h. Let $n_r^i(p_h)$ denote an experience weight that seller i assigns to the number of rounds up to and including round $r-1$ in which he previously offered p_h, independent of his cost. Then $\beta_r^i(b_1|p_h)$ is updated after each round as follows:

$$\beta_r^i(b_1^*|p_h) = \begin{cases} \frac{n_{r-1}^i(p_h)\cdot\beta_{r-1}^i(b_1^*|p_h)+1}{n_r^i(p_h)} & \text{if } i \text{ offered } p_h \text{ in } r-1 \text{ and buyer's response is } b_1^* \\ \frac{n_{r-1}^i(p_h)\cdot\beta_{r-1}^i(b_1^*|p_h)}{n_r^i(p_h)} & \text{if } i \text{ offered } p_h \text{ in } r-1 \text{ and buyer's response is } b_1 \neq b_1^* \\ \beta_{r-1}^i(b_1^*|p_h) & \text{if } i \text{ offered } p_l \text{ in } r-1 \end{cases} \tag{13}$$

The experience weight is updated in the following way: $n_r^i(p_h) = n_{r-1}^i(p_h) + 1$ if in round $r-1$ the initial offer was p_h, and $n_r^i(p_h) = n_{r-1}^i(p_h)$ otherwise. Let $\mu_{c,r-1}^{*i}$ be the realized continuation payoff in round $r-1$, and $n_{c,r-1}^i(p_h, rej)$ denote an experience weight that seller i with cost c assigns to the number of rounds up to and including $r-1$ in which he previously offered p_h and rejected in $t = 2$[12]. $n_{c,r}^i(p_h, rej)$ follows a similar updating rule as $n_r^i(p_h)$, but takes into account only rounds in which the seller with cost c offered p_h and rejected in $t = 2$. Then the expected continuation payoff in round r is updated as:

$$\mu_{c,r}^i(p_h, rej) = \begin{cases} \frac{n_{c,r-1}^i(p_h,rej)\cdot\mu_{c,r-1}^i(p_h,rej)+\mu_{c,r-1}^{*i}}{n_{c,r}^i(p_h,rej)} & \text{if } i\text{'s action profile was } (p_h, rej) \text{ in } r-1 \\ \mu_{c,r-1}(p_h, rej) & \text{otherwise} \end{cases} \tag{14}$$

The initial values $\beta_0^i(b_1|p_h)$ and $\mu_{c,0}^i(p_h, rej)$ are calculated as simple means from all observations in round 1.[13] The initial values of the experience weights $n_0^i(p_h)$ and $n_{c,0}^i(p_h, rej)$ are assumed to be equal to n_0 for all updating processes.[14] The parameter n_0 is estimated jointly with all other parameters from the data. The initial values can be thought of as reflecting previous experience, either due to learning transferred from different games or due to introspection.

Now we define the log-likelihood for the entire sample. Denote by $R_1 = [1, 7]$, $R_2 = [8, 13]$, $R_3 = [14, 20]$ the three blocks that the 20 rounds are divided into, and by $R = [1, 20]$ the set of all 20 rounds played. Let $a(R)$ be the set of all observed

[12] Note that since the continuation payoff here also depends on the seller's cost c, the experience weight only considers rounds in which the seller had cost c.

[13] If there were no observations of any subject in this position in round 1, we look for the first round in which we find such observations.

[14] We assume that only i's actual experience in different roles results in different values. We interpret n_0 as if this was the number of prior observations before the game starts.

actions of all individuals in all rounds. Let $\gamma_k^{R_j}$ denote subjects' common prior k-type probability in block R_j and $\gamma^{R_j} = \left(\gamma_1^{R_j}, \gamma_2^{R_j}, \gamma_3^{R_j}\right)$. The log-likelihood for the entire sample is:

$$\begin{aligned} &\ln L\left(\gamma, \lambda, \epsilon_1, \epsilon_2, n_0 | a(R)\right) \\ &= \sum_{j=1}^{3}\sum_{i=1}^{N} \ln\left(\sum_{k=1}^{3} \gamma_k^{R_j} \prod_{r\in\{R_j\}} \left[P_{c,r}^{i,k}\left(a_1, a_2\right)\right]^{1-I(r)} \left[P_{c,r}^{i,k}\left(a_1\right)\right]^{I(r)}\right) \end{aligned} \quad (15)$$

where $\gamma = \left(\gamma^{R_1}, \gamma^{R_2}, \gamma^{R_3}\right)$ and $I\left(r\right) = 1$ if the game ends in $t = 1$ and 0 otherwise.

Computing the probability γ_k, $k = 1, 2, 3$ for the seller's types in the 3 blocks (see Table 5) we find that the adjusting type explains the behavior of more than one half of the sellers in all three blocks. Type 2, whose behavior would be consistent with risk-averse behavior, explains about 20% of the population. We do not find any significant changes in the type composition over the three blocks, however, that does not mean that subjects do not learn. In fact, the adjusting type always updates the priors according to past observations and recalculates the best response in each round, thus taking into account changes of the opponent's behavior. As first mover, the seller needs to anticipate the buyer's upcoming decision, and thus using one's own past experience to estimate the probability of a buyer' s acceptance of p_h seems to explain the observed behavior of sellers better than the prediction that relies on an exogenously given prior.

Table 5: Estimates of Behavioral Types in `NOO`

		Sellers				Buyers			
Block	Param.	Coef.	Std.Err.	z	$Pr > \|z\|$	Coef.	Std. Err.	z	$Pr > \|z\|$
	γ_1	.215	.108	1.98	.047	.258	.102	2.51	.012
1	γ_2	.215	.095	2.25	.024	.000	.	.	.
	γ_3	.569	.129	4.40	.000	.741	.102	7.21	.000
	γ_1	.054	.070	0.78	.438	.247	.158	1.56	.118
2	γ_2	.182	.084	2.15	.032	.262	.109	2.40	.010
	γ_3	.762	.102	7.42	.000	.489	.164	2.97	.003
	γ_1	.235	.110	2.14	.033	.441	.151	2.91	.004
3	γ_2	.215	.105	2.06	.040	.122	.088	1.39	.166
	γ_3	.548	.132	4.14	.000	.435	.147	2.96	.003
	λ	1.42	.211	6.75	.000	.776	.118	6.56	.000
	n_0	40.62	5.44	7.46	.000	25.67	28.24	0.91	.363
	ϵ_1	.031	.027	1.13	.260	.017	.040	0.43	.670
	ϵ_2	.007	.027	0.29	.775	.107	.048	2.21	.027
log likelihood		-237.89				-247.10			

Computing the probabilities for the buyer's types in the 3 blocks we find that the adjusting type explains the behavior of 3/4 of the population in the early block, while in the late block about 20% of them seem to switch to the prediction type. A closer look at the best responses of the adjusting type shows that in the late block, accepting all offers is the best response for most buyers, which just coincides with the prediction, hence a clear assignment to one of these two types is not possible.[15]. Type 2, consistent with risk-loving behavior, increases significantly from almost zero in block 1 to 26% in block 2, while it is decreasing again in the last block. This corresponds to the descriptive results from Table 4.

To evaluate how well our model is explaining the data, we counted how many observations correspond precisely to the behavior of the type they are assigned to. Using the estimated parameters we calculated for each individual and each block the probability to obtain the observed data, assuming that the individual is of a given type. Using Bayes' rule, we then calculated the (posterior) probability that the individual is of a certain type in this block, given the observed data in this block. We assign each individual to the type that gives us the highest posterior probability. We then use the assigned type for each individual in a block and check if the observed behavior of the individual coincides with the predicted behavior of this type. This way, we calculated the proportion of observations where subjects behaves exactly like the type they were assigned to. In `NOO`, we found 80.7% of exact forecasts for sellers and 82.1% for buyers.

4.3 Bargaining with Search as Outside Option

In treatments `GOO` and `BOO`, an outside option consisting of search was introduced for buyers. Recall that all games in `GOO` should end in the search phase (see Table 1). In `BOO`, theory predicts a bargaining agreement on p_l for HV-LC, while for all other pairs the game should end in the search phase.

Agreements: Figure 5 displays the proportion of rounds that ended in the bargaining phase for the various pairs in both treatments.[16] The only observations that correspond to the predictions are the high proportion (96%) of agreements between two flexible agents (LC-HV) in `BOO` and almost no agreements between two inflexible agents in both treatments (2% and 5%, resp.). For all other pairs, we find bargaining agreements where search was predicted. But despite the fact

[15] We looked at post-estimation probabilities for every strategy (a_1, a_2) for each individual buyer over the 20 rounds if they were all behaving as adjusting types. Here, in the early block the probability of accepting all offers is rather close to that of initially rejecting p_h and accepting it in $t = 2$, i.e. they have similar expected values, while in the late block the strategy of accepting all offers has a much higher expected value for all individuals, and is thus chosen as best response by the adjusting types. This coincides with the prediction strategy. For sellers, on the other hand, the best response changes over time, thus the adjusting type is more clearly identified.

[16] These numbers include games that ended in a disagreement initiated by a seller, since we want to separate bargaining from search. Figure 6 contains more information about the disagreements.

that search rates were overall lower than predicted, Figure 5 shows that monetary incentives of the outside option do matter: The better the outside option compared to the expected bargaining outcome, the higher the proportion of games that end in the search phase. Consider the outcomes in GOO: Buyers have the lowest incentive to search in games between LC-HV, as they can make a profit of 20 from bargaining and 20.9 (in expectation) from search. Here only 26% of the games ended in the search phase. Search becomes more attractive for buyers in HC-HV pairs, as they can get only 14 from bargaining, and we observe 67% of these games ending in the search phase. LV buyers paired with LC sellers can get at most 1 from bargaining but can expect 8.1 from search, and we find 87% who take the outside offer in this case, whereas in HC-LV pairs, no gains are to be expected from bargaining and we have 98% of the buyers searching. The results are similar for BOO, but the proportion of bargaining agreements here is significantly higher than in GOO for each type of pairs (χ^2, $Pr < .001$).

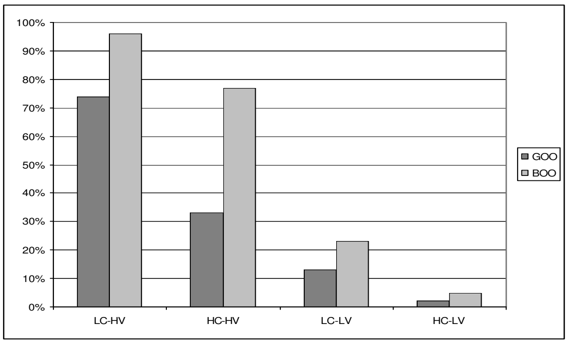

Figure 5: Bargaining vs. Search: Games Ending in Bargaining Phase

Bargaining outcomes: Figure 6 shows in more detail the allocation of the bargaining surplus for both search treatments from B's perspective, given that the game ended in the bargaining phase. In GOO, 93% of those HV buyers who reached an agreement with LC sellers received the high surplus, thus rejecting a search option that offers only slightly more. In BOO, 23% of the HV buyers that did not opt out accepted even the low surplus from LC sellers. In HC-HV pairs, where S can only offer p_h or quit without making losses, we find that p_h was accepted by over 85% of HV buyers who did not opt out in GOO and 95% in BOO. This corresponds to 30% of *all* HV buyers in GOO who accept p_h when offered, thus preferring the certain surplus of 14 over the expected 20.9, while in BOO 73% prefer the sure 14 over the expected 16.7 from search.

Search Outcomes: Table 6 shows the accepted outside options for each type of buyer in both treatments, as well as the predicted means. The latter are derived from the optimal reservation prices, i.e. if the optimal stopping rule prescribes for HV buyers to accept a price of 16.1 or less in GOO, then one would predict the mean

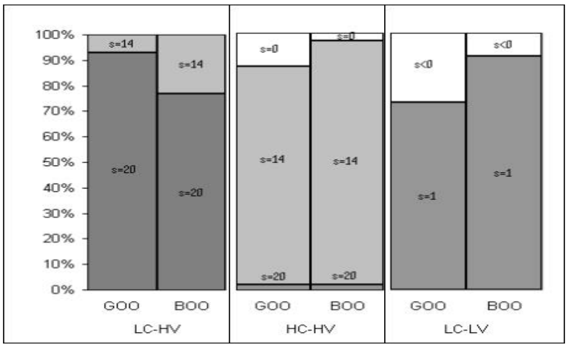

Figure 6: Buyers' Surplus from Bargaining in Treatments GOO and BOO

of all accepted outside offers to be 8.1, since all search offers are equally likely. In fact, we observe a mean of 8.9 in GOO. In BOO it is 10.6 when 10.2 was predicted. For LV buyers, the mean accepted outside offers are less close to the predictions: 6.6 in GOO when the prediction was 5.0, and 8.7 in BOO when the prediction was 6.1. Significant differences between the mean accepted outside offers are thus found between HV and LV buyers (MWU test for GOO: $Pr < .001$, BOO: $Pr < .08$), while a test of difference between treatments is only significant for LV buyers (MWU: $Pr < .002$).[17]

Table 6: Outside Offers Accepted by HV and LV Buyers*

Type	**Accepted Outside Offers**					
	# Obs.	Pred.Mean	Obs.Mean	Std.Dev.	Min	Max
HV buyers	108	8.1	8.9	5.7	.1	23.1
	27	10.2	10.6	6.3	.8	22.4
LV buyers	222	5.0	6.6	4.3	.2	17.8
	173	6.1	8.7	6.7	.1	47.8

* observations for GOO are reported in upper left, for BOO in lower right of each cell

All mean accepted outside options are far below p_l, which seems to suggest that profits from search are higher than profits from bargaining. However, the discount factor of .8 causes a sharp decrease in actual profits when they are earned in a later period, thus realized profits shall be considered in Table 7. In GOO, all HV buyers could be pooled from a theoretical point of view, since they are all predicted to search; their mean profit from bargaining of 17.3 is lower than the mean profit from search of 20.0 (two-sample Wilcoxon rank-sum test, $Pr < .001$). However, if we consider them separately in LC-HV pairs and HC-HV pairs, the former do not

[17]Note that for BOO we have few HV buyers who search; this might be the reason why the difference in mean accepted outside offers is visible but not significant.

Table 7: Buyers' Profits by Types*

Game End	Pair	Profits			
		# Obs.	Pred.Mean	Obs.Mean	Std.Dev.
Bargaining	HV-LC	87	20	19.4	1.7
		99	20	18.2	2.6
	HV-HC	46	14	12.1	4.9
		90	14	13.2	3.2
	LV-LC	15	1	-.3	2.2
		21	1	.4	1.5
	LV-HC	2	-	-1.1	3.0
		9	-	-.7	1.3
Search	all HV	108	20.9	20.0	5.3
		27	16.7	14.1	7.8
	all LV	222	8.1	7.5	5.3
		173	5.9	5.0	4.2

* observations for `GOO` are reported in upper left, for `BOO` in lower right of each cell

attain a significantly higher profit from search compared to bargaining (20.0 vs. 19.5), while the latter do (20.0 vs. 12.1, $Pr < .000$, MWU). Not surprisingly, also LV buyers' profits from bargaining are significantly lower than those from search, as they can make at most a profit of 1 from bargaining, and given individual rationality, search thus must yield higher profits.

In `BOO`, theory predicts that HV buyers' behavior depends on who they are paired with: They should have reached an agreement with LC sellers, and we observe most HV buyers did just this, however, not always on the predicted p_l. As Table 7 shows, the average profit from bargaining is only 18.2, when 20 is expected. On the other hand, they should have opted out when paired with HC sellers, as the expected profit from search is higher than from bargaining. We find less than one quarter of these buyers searching. On average, they were no worse off accepting p_l from bargaining than trying their luck with search. The average profit of 14.1 from search is not significantly higher than the profit of 13.2 from bargaining, and quite below the expected profit from search of 16.7. These numbers point towards a suboptimal search strategy in `BOO`, however one also has to consider that the number of observations in this class is small.

Bargaining behavior: Even though the design of our experiment leaves little room for revealing social preferences, subjects may now avoid extremely asymmetric outcomes at a much smaller cost than in `NOO` by choosing a bargaining outcome over search. However, this does not seem to be a convincing explanation for the high number of agreements: We find that 45% of all HV buyers in `GOO` choose to search, thus revealing little concern for the bargaining partner who is left with a zero payoff in this case. When the outside option is much worse in BOO, the proportion of buyers who opt out drops to 13%, but this comparison between the two treatments shows that observed behavior strongly considers the opportunity cost in the decision problem, and thus equitable outcomes do not seem to be the decisive factor in decision making here. As for LV buyers' behavior, we observe disagreements in 87% of LC-LV pairs in GOO and 77% in BOO, i.e. the vast majority of LV buyers prefers to opt out even though this implies that their bargaining partner receives zero. This is particularly notable when S offers p_l and thus reveals his type. Then B knows that an agreement with S is possible, and with his decision to opt out S foregoes a profit of 14. In GOO, of the 116 LC-LV pairs we find 81 low-cost sellers who offer p_l immediately and 71 buyers responded with the decision to search.

Looking for a plausible explanation for the observed bargaining outcomes which were not predicted for BOO and GOO, we use again the idea that subjects have homemade beliefs about the opponent's behavior, as already described in NOO. For this purpose, we have to consider buyers' reaction to sellers' offers to see whether the latter is consistent with the former. We look at individuals' behavior over the course of the 20 rounds. First, we note that the experimental data shows a significant number (42%) of subjects in the role of sellers who offer p_l in every round of BOO as predicted, while only 20% do so in GOO. However, we find that 50% of subjects in the role of sellers offer p_h more often in BOO than in GOO. This is not only a contradiction to the prediction but also to simple risk-aversion on sellers' side, as p_l increases the chance for an agreement in BOO. Now consider how buyers respond to p_h: 68% of HV buyers in BOO accept p_h, which corresponds to 35% of all buyers. This is quite close to the critical value of $\bar{\pi}_B = 0.32$, at which a seller should just be indifferent between the two possible offers. Thus, sellers have no real incentive to change their initial offer towards p_l when they have low cost. In fact, their initial offers do not change significantly over time (Pearson χ^2: Pr=0.4). In other words, besides the significant proportion (42%) of LC sellers who always offer p_l according to the prediction, 58% of LC sellers sometimes conceal their type despite the buyer's outside option. Over two thirds of HV buyers respond by accepting p_h, which confirms that sellers' homemade beliefs about their behavior are far from wrong, and therefore they make little adjustment over the last 10 rounds, which should be reflected in our econometric analysis in section 4.4.

In GOO, HV buyers learn to search over time. The search rate for HV buyers in $t = 1$ is increasing from 39% in the early block to 67% in the late block. Their acceptance rate of p_h decreases from 33% to 22%. In view of the buyers' adjustments, in particular the higher search rates, LC sellers have little to respond with, as they cannot adjust in a meaningful way. In the next subsection we will test the model with different types of behavior for GOO and BOO.

Most games that end in a bargaining agreement are very time efficient. Over

Table 8: Violations of Optimal Stopping Rule*

Type	$p > p^*$ # Obs.	accepted	in games	$p \leq p^*$ # Obs.	rejected	in games
HV buyers	53	0.26	14/53	104	0.09	5/89
	59	0.03		39	0.39	4/21
LV buyers	284	0.20	57/284	192	0.15	9/157
	494	0.09		150	0.15	9/121

* obs for GOO are reported in upper left, for BOO in lower right of each cell

90% of the agreements are achieved in the first period of bargaining. These results do not depend on experience, as we see about one half of the agreements occur in rounds 10-20. The obvious question then is whether buyers who went for the risky option of search did better on average, as predicted in the theoretical model. This implies, of course, that their search behavior was efficient, which shall be investigated in the paragraph below.

Search Behavior: Buyers' search behavior was more successful than accepting a random outside offer: Significant differences are found when comparing the mean profits from the accepted outside options to the mean profit from all drawn outside options (Wilcoxon, $Pr < .001$ for both buyer types and both treatments). This is also true when we compare the actual profits to the profit they would have made if they had accepted the first outside offer they received. The search profits for all buyers in `GOO` as well all those for LV buyers in `BOO` are actually rather close to the expected profits from search. Thus, search behavior *per se* was, if not optimal, then at least quite successful in terms of payoff efficiency. This result does not vary significantly over experience levels of players and is consistent with previous search experiments.

As for the length of search, while in `GOO` only about 10% of the HV buyers searched for more than 2 periods, 25% of the LV buyers do so. The median search length for HV buyers is less than for LV buyers (Kruskal-Wallis, $Pr < .01$). This result is in line with the lower optimal reservation price for LV buyers, assuming that both types display a similar risk attitude. In `BOO`, about 50% of both HV and LV buyers search for more than two periods, and period 8 is reached when about 90% of both HV and LV buyers have ended search. The median search length for the two buyer types is not significantly different in this treatment.

We now check to which extent behavior during search is consistent with the optimal stopping rule. Table 8 describes the two possible directions of violation of this rule. Note that with $p \leq p^*$ a subject may violate the optimal stopping rule repeatedly within a single game, which can lead to a seemingly high number of rejections of prices below p^*. This is why we include not only the instances but also the number of games in which such violations were observed.[18] In GOO, we find similar behavior for HV and LV buyers: there are more games in which they accept an outside offer when they should have rejected than games in which they reject an offer when they should have accepted (Pearson χ^2, $Pr = .000$). This is consistent with the "too little search" results found in previous experiments and includes risk-aversion as possible explanation for the observed behavior. In BOO, however, we find no difference in the direction of violation for LV buyers, while HV buyers seem to reject $p \leq p^*$ more often than they accept $p > p^*$ (Pearson χ^2, $Pr < .05$). These violations would be consistent with too much search, i.e. with a risk-loving attitude. However, of the total of 15 instances of rejections of $p \leq p^*$, 13 were repeated rejections by 2 subjects within a single game. All violations were concentrated on a few rounds in the middle of the experiment (rounds 7,10,15), which speaks against a persistent pattern. Furthermore, HV buyers' behavior is not significantly different from LV buyers' neither for acceptance of $p > p^*$ (Pearson χ^2, $Pr = 0.15$, Fisher exact $Pr = 0.21$) nor for rejection of $p \leq p^*$ (Pearson χ^2, $Pr = 0.13$, Fisher exact $Pr = 0.23$). Therefore, we believe that too much search is not a persistent pattern in this experiment.[19] These results also support for Sonnemans' (1998) hypothesis that subjects who follow stopping rules that imply too little search perform rather well, while those using stopping rules that imply too much search obtain poor results. The latter are thus more likely to be revised downwards, so on average subjects search too little.

In order to help identify risk aversion as opposed to satisficing as a driving factor of search behavior, we tested whether subjects showed a tendency to accept the first offer they encountered during search that exceeded the highest offer rejected in the bargaining phase, adjusted for discounting.[20] Given that a particular outside option was accepted, the number of those accepted when they were the first offer below the rejected bargaining offer was significantly higher than those that were not the first outside offer found that was below the rejected bargaining offer (T2: $Pr = .000$, T3: $Pr = 0.038$). This points to risk-aversion during search rather than satisficing behavior with the goal to attain a certain profit level.

Overall, the results confirm what we already found in the analysis of the search outcomes: Buyers search quite efficiently. The high number of observations and the observed efficiency for search behavior suggests that despite the relatively complex situation with uncertainty, subjects are able to make very good decisions.

[18] Note that for the other direction of violation, i.e. when $p > p^*$ is accepted, each instance of violation must come from a different game.

[19] Zwick et al. (2003) identified some behavioral decision rules for the observed patterns when subjects searched too much or too little. These rules, however, are not applicable for our game, as they were developed for a particular search framework where alternatives differed in multiple dimensions, and a realization yielded only limited information about the value of the alternative.

[20] This was suggested by an anonymous referee.

Return to Bargaining: Recall that for both treatments, theory predicts that buyers will never return to bargaining after they left S, i.e. in equilibrium, a bargaining-search game with the option to return and a game without such option are identical. We find that there are only 6 games out of 240 in `GOO`, where the option to return to bargaining was taken, and this happens across the three blocks of games. In `BOO`, return to bargaining is observed more often but declines monotonically over time: in 13% of the rounds of block 1, in 8% of block 2 and less than 1% in block 3. Thus, when players are more experienced, this inefficient behavior of returning to bargaining disappears, which is in line with the theoretical prediction.

4.4 Econometric results of `GOO` and `BOO`

Similarly to the analysis in `NOO`, we consider the following three types:

Sellers (in both treatments): A LC seller of type 1 (prediction) immediately offers p_l. A LC seller of type 2 (risk-loving) offers p_h and accepts p_l in $t = 2$. HC sellers of both types always offers p_h. Type 3 (adjusting) plays a best response according to the past experience.

Buyers: A HV buyer of type 1 (prediction) accepts p_l in `BOO`, otherwise opts out. A HV buyer of type 2 (risk-averse) accepts all offers. LV buyers of Type 1 and 2 always opt out. Type 3 (adjusting) plays a best response according to the past experience.

The behavioral model for all types is set up as in `NOO`, we just have to replace the option to quit by opting out for buyers in order to describe the corresponding strategy set for `GOO` and `BOO`, where the adjusting type chooses the best response from. The expected value from search is treated as a continuation payoff and thus calculated in the same way. Note, however, that types 1 and 2 are not directly comparable across all treatments: Due to the small action space we are not able to distinguish between a seller of type 1 and a risk-averse seller for `GOO` and `BOO`, while in `NOO` the action of a type 1-seller coincides with that of a risk-loving seller. A similar argument applies for buyers. Type 2 thus also describes different risk attitudes for `NOO` and `GOO`/`BOO`.

We first report the results of an unconstrained estimation, where the parameters for λ, n_0, ϵ_1 and ϵ_2 are estimated separately for each treatment. Table 9 shows that for `GOO`, about 80% of sellers' behavior in the first block is explained by the prediction type 1 with the unconditionally revealing strategy. However, it decreases significantly over time down to 1/3, while the risk-loving type 2 appears to be significant only in the late block. This may be explained by buyers' increasing choice of opting out, in which case seller's offer becomes irrelevant. The adjusting type 3 gains importance over time: from an insignificant proportion in the early block it rises to about 1/3 of the population in the middle block, and to almost

Table 9: Estimates of Behavioral Types in `GOO` and `BOO` - Unconstrained Model

		Sellers				Buyers			
GOO									
Block	Param.	Coef.	Std.Err.	z	$Pr > \lvert z \rvert$	Coef.	Std. Err.	z	$Pr > \lvert z \rvert$
	γ_1	.799	.160	4.97	.000	.000	.	.	.
1	γ_2	.155	.113	1.37	.171	.372	.120	3.08	.002
	γ_3	.045	.110	0.41	.683	.627	.120	5.19	.000
	γ_1	.500	.221	2.26	.024	.000	.014	0.01	.996
2	γ_2	.131	.092	1.41	.158	.335	.105	3.17	.002
	γ_3	.368	.222	1.65	.098	.664	.106	6.22	.000
	γ_1	.339	.157	2.15	.032	.149	.087	1.72	.085
3	γ_2	.184	.099	1.86	.062	.208	.084	2.47	.014
	γ_3	.476	.162	2.93	.003	.642	.110	5.84	.000
	λ	1.00	.298	3.37	.001	.578	.051	11.18	.000
	n_0	1.76	.567	3.11	.002	11.07	3.74	2.96	.003
	ϵ_1	.215	.058	3.70	.000	.050	.064	0.79	.428
	ϵ_2	.293	.112	2.61	.009	.198	.045	4.32	.000
log likelihood			-194.75				-267.13		
BOO									
Block	Param.	Coef.	Std.Err.	z	$Pr > \lvert z \rvert$	Coef.	Std. Err.	z	$Pr > \lvert z \rvert$
	γ_1	.666	.125	5.30	.000	.075	.076	0.98	.326
1	γ_2	.152	.103	1.47	.142	.587	.148	3.96	.000
	γ_3	.181	.111	1.62	.104	.336	.129	2.60	.009
	γ_1	.657	.169	3.89	.000	.192	.098	1.96	.050
2	γ_2	.000	.000	0.01	.995	.807	.098	8.22	.000
	γ_3	.342	.169	2.02	.043	.000	.	.	.
	γ_1	.674	.136	4.96	.000	.136	.084	1.61	.107
3	γ_2	.000	.	.	.	.791	.107	7.38	.000
	γ_3	.325	.136	2.40	.017	.072	.073	0.98	.325
	λ	.925	.204	4.52	.000	.274	.062	4.43	.000
	n_0	3.29	1.58	2.08	.037	.780	.028	27.71	.000
	ϵ_1	.176	.039	4.50	.000	.147	.071	2.05	.041
	ϵ_2	.507	.214	2.36	.018	.162	.034	4.67	.000
log likelihood			-168.98				-237.37		

50% in the late block. Many of the subjects thus stop following an unconditionally revealing strategy, but take into account their expectations about buyers' behavior. A significant proportion of over 1/3 of buyers in the first two blocks follow the risk-averse behavior of type 2, i.e. they accept all offers. The prediction type 1 appears only in the late block, and explains about 15% of the buyer population, i.e. unconditional search explains little of the data. The adjusting type of buyers explains the behavior of about 2/3 of the population throughout all three blocks, indicating that while many buyers learn to search, this is not unconditional but rather dependent on the seller's offer and past experience.[21]

From Table 9 we see that in `BOO` about 2/3 of the sellers can be classified as the prediction type 1 throughout all blocks, which is consistent with the descriptive result above that in BOO more sellers offer p_l in all 20 rounds. In contrast to `GOO`, the risk-loving type 2 is quasi non-existent, while we find that the adjusting type explains about 1/3 of the sellers' behavior in the last two blocks. Calculating the post-estimation probability with which an adjusting seller actually chooses p_h as best response shows that it is less than .2 in all rounds of `GOO`, while it is always above .6 in `BOO`. In other words, the adjusting types choose p_h more frequently in `BOO`, which is also what we observed in the descriptive part. This, in turn, is consistent with buyers' behavior: Table 9 shows that the risk-averse type 2 explains a high proportion (80%) of buyers' behavior in `GOO`. Thus, there are two important ways to explain sellers' behavior here: while a vast majority considers that a concealing strategy may seem more risky since an agreement is more likely than in `GOO`, about 1/3 of the sellers learn from buyers' risk-averse behavior that it is worth taking into account buyers' past behavior in order to decide which action to take. To evaluate how well our unconstrained model is explaining the data, we counted again how many observations correspond precisely to the behavior of the type they are assigned to, as described in `NOO`. For `GOO`, we found 90.0% of exact forecasts for sellers and 91.2% for buyers, while for `BOO`, we found 89.8% of exact forecasts for sellers and 87.2% for buyers.

In order understand what our structural model can explain about fundamentals, we estimated a constrained model in which the parameters λ, n_0, ϵ_1 and ϵ_2 are the same across all treatments (see Table 10), and compared the results to the unconstrained model. The likelihood ratio test rejects the constrained model for both sellers ($p < .000$) and buyers ($p < .002$). We thus conclude that our structural model does not predict observed behavior well without sufficiently many free parameters. A comparison of the estimated parameters from the unconstrained model shows that there are rather large differences across treatments, in particular between the estimates of n_0, which refers to the sensitivity of subjects' homemade beliefs. For `NOO` these are very high, which should be interpreted as a slow adjustment of subjects' homemade beliefs. This, however, does not imply that the adjusting type is not meaningful in this treatment, since even a small change in (homemade) beliefs may result in a different best response-strategy in a later game, if different strategies have rather close expected payoffs in a game. The differences in the parameter estimates for `NOO` and `GOO`/`BOO` might also be taken as

[21] Post-estimation probabilities for the adjusting type of buyers show that when the offer is p_l, the best response is always to accept, due to low initial expected search values, and is reinforced through little updating. When the offer is p_h, the expected value from rejecting and searching in $t = 2$ is close to that of immediate search in the late block. Thus, although we observe more search in later rounds, the adjusting type can better explain behavior than the prediction type.

an indication that subjects consider a game with and one without outside option as different situations. Our model then reports differences in behavior and adjustment across treatments possibly because the situations require different learning, understanding, and abilities by subjects.

Table 10: Estimates of Behavioral Types - Constrained Model

		Sellers				**Buyers**			
NOO									
Block	Param.	Coef.	Std.Err.	z	$Pr > \|z\|$	Coef.	Std. Err.	z	$Pr > \|z\|$
	γ_1	.170	.159	1.07	.284	.275	.106	2.60	.009
1	γ_2	.255	.095	2.66	.008	.000	.	.	.
	γ_3	.573	.175	3.27	.001	.724	.106	6.83	.000
	γ_1	.000	.003	0.00	.997	.336	.141	2.37	.018
2	γ_2	.192	.094	2.03	.042	.281	.114	2.45	.014
	γ_3	.807	.094	8.54	.000	.381	.155	2.49	.014
	γ_1	.192	.117	1.64	.101	.501	.141	3.54	.000
3	γ_2	.281	.135	2.08	.038	.118	.085	1.39	.165
	γ_3	.526	.166	3.16	.002	.380	.143	2.65	.008
GOO									
Block	Param.	Coef.	Std.Err.	z	$Pr > \|z\|$	Coef.	Std. Err.	z	$Pr > \|z\|$
	γ_1	.850	.132	6.42	.000	.000	.	.	.
1	γ_2	.127	.094	1.35	.176	.386	.132	2.91	.004
	γ_3	.021	.088	0.25	.804	.613	.132	4.62	.000
	γ_1	.814	.270	3.01	.003	.000	.	.	.
2	γ_2	.133	.086	1.54	.125	.345	.106	3.25	.001
	γ_3	.052	.250	0.21	.835	.654	.106	6.15	.000
	γ_1	.443	.171	2.59	.010	.154	.086	1.79	.073
3	γ_2	.260	.102	2.53	.011	.211	.084	2.49	.013
	γ_3	.296	.150	1.97	.049	.633	.109	5.80	.000
BOO									
Block	Param.	Coef.	Std.Err.	z	$Pr > \|z\|$	Coef.	Std. Err.	z	$Pr > \|z\|$
	γ_1	.738	.104	7.05	.000	.024	.083	0.29	.769
1	γ_2	.261	.104	2.49	.013	.903	.111	8.09	.000
	γ_3	.000	.	.	.	.072	.069	1.03	.302
	γ_1	.816	.096	8.47	.000	.145	.085	1.69	.091
2	γ_2	.089	.095	0.94	.350	.854	.085	9.95	.000
	γ_3	.094	.084	1.12	.262	.000	.	.	.
	γ_1	.775	.099	7.78	.000	.118	.077	1.52	.127
3	γ_2	.109	.124	0.88	.378	.820	.108	7.59	.000
	γ_3	.115	.122	0.94	.346	.061	.079	0.76	.444
	λ	1.63	.235	6.95	.000	.575	.043	13.33	.000
	n_0	43.31	16.111	2.69	.007	9.72	.086	112.02	.000
	ϵ_1	.188	.030	6.25	.000	.043	.027	1.59	.113
	ϵ_2	.164	.046	3.55	.000	.204	.022	8.96	.000
log likelihood			-624.41				-763.48		

5 Conclusion

This experimental study reports on three incomplete-information bargaining games between a seller and a buyer, where the buyer may have an outside option consisting of sequential search. In the pure bargaining game, more than one half of the sellers prefer to reveal their type, thus renouncing to the high surplus, when standard theory predicts a concealing offer. Even less strategic behavior is observed with experience. We believe that a behavioral model in which subjects have homemade beliefs about the opponent's behavior, where they best respond to these beliefs, and adjust them according to their own past observations, explains the observed data of the bargaining game better than the prediction that uses only the priors that were explicitly given by the experimenter.

In the two bargaining and search games we varied the quality of the outside option. In the treatment with a good outside option, we found that many high-value buyers prefer a sure profit from bargaining to a search outcome with a higher expected value. When the outside option is bad, acceptance for the low surplus from bargaining further increases. Overall, we find for both treatments and for all combinations of types that many more bargaining agreements are reached when search is predicted to be optimal. A combination of homemade beliefs and risk-aversion explains the divergence between prediction and observations. This explanation is also consistent with behavior observed in the pure bargaining game. However, a structural model which constrains the parameters regarding learning and homemade beliefs to be the same for all three treatments is rejected.

Search behavior is very efficient and on average never leads to worse outcomes than bargaining. Over 80% of the buyers' behavior is consistent with the exact optimal stopping rule for search. While we do not assume that subjects consciously follow this rule, the observation suggests that they have a good intuition when dealing with uncertainty in simple random draws, and they fully understand the no-delay rule. Violations of the optimal stopping rule are mostly explained by too little search, which is consistent with risk-averse behavior during search.

Although our setup does not provide a general answer to the question of bargaining and search behavior with similar conditions for the offer spaces, it yielded interesting results while keeping the frame simple enough for subjects to deal with. We find it noteworthy that search behavior was rather close to the prediction, while bargaining behavior showed quite some deviations the discrete offer space cannot have been responsible for. Our behavioral model finds sellers' and buyers' behavior mostly consistent, but our design does not allow us to clearly separate risk-aversion from homemade beliefs to explain the observed data. This would be a task for future research.

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7 Appendix

7.1 Instructions for Treatment NOO

General Information

In this experiment you will face a decision problem involving two people. The decision problem will subsequently be denoted as "game", and the people participating in it will be denoted as "players". One of the two players in a game is always a "Seller" and the other one a "Buyer". You will bargain over a price for an object. The bargaining proceeds via computer. No verbal communication is possible.

Participants in this experiment are divided into two groups, the group of Sellers and the group of Buyers. Whether you are a Seller or a Buyer will be determined in the beginning of the first game, and you will keep this role for the entire experiment.

You will play 20 games in this experiment. In each game, you will be randomly matched with another participant in this room. He/she will remain anonymous and will change from one game to another. It is possible that you encounter the same partner again. Your partner will only be informed about your decision, but not about your name or your participation number, i.e., **your decision will be completely anonymous**. Each player will be informed about his/her own payoff in each game, but not about the partner's payoff.

After a game is finished, you will be randomly matched with another person to play a new game. **At the end of the experiment, two games will be drawn at random, and each participant will receive his/her payoffs from these two games in real money.**

The Game

In each of the 20 games, you will bargain over the price of a (fictitious) object, which you can buy if you are a Buyer, or sell if you are a Seller. Each game consists of several rounds. You will keep the same partner for all rounds of a game. Once a new game starts, you will be matched with a different partner. **All participants receive the same information about the game.**

The Sellers
Each Seller has a certain cost of selling the object. At the beginning of a game, each Seller will be informed about his/her cost, which is determined by a random draw of the computer:

- There is a 50 % chance that a Seller has a **low cost of $**3.
- There is a 50 % chance that a Seller has a **high cost of $**22.

Only these two cost levels are possible. A Seller's cost remains the same in all rounds of a game. Once a new game starts, there is a new random draw with a $50 - 50$ chance for each Seller of having a high or low cost.

The Seller's profit
If a Seller and a Buyer come to an agreement over the price, the Seller's profit is calculated in the following way:

Seller's profit = accepted price offer - Seller's cost

Thus, if the Seller and the Buyer agree on a price that is above the Seller's cost, the Seller will make a profit. If the price is below the Seller's cost, he will make a loss. If they don't agree on a price, both Seller and Buyer get a profit of zero.

The Buyers
Each Buyer has a certain valuation for the object. At the beginning of a game, each Buyer will be informed about his/her valuation, which is determined by a random draw of the computer:

- There is a 50 % chance that a Buyer has a **high valuation of $**37**.**
- There is a 50 % chance that a Buyer has a **low valuation of $**18**.**

Only these two valuations are possible. A Buyer's valuation remains the same in all rounds of a game. Once a new game starts, there is a new random draw with a $50-50$ chance for each Buyer of having a high or low valuation.

The Buyer's valuation and the Seller's cost are randomly determined and independent from each other.

The Buyer's profit
If a Seller and a Buyer come to an agreement over the price, the Buyer's profit is calculated in the following way:

Buyer's profit = Buyer's valuation - accepted price offer

Thus, if they agree on a price that is below the Buyer's valuation, the Buyer will make a profit. If the price is above the Buyer's valuation, he will make a loss. If they don't agree on a price, both Seller and Buyer get a profit of zero.

The Bargaining

Round 1
In Round 1, the Seller will start by making an offer to the Buyer. **This offer can be either** 17 **or** 23**. No other offers are possible.** The Buyer will be informed about the Seller's decision and will then be asked to choose between one of the following three options:

The Buyer's options:
- He can accept the Seller's offer (**"accept"**). In this case, the game is over and the profits of each player are calculated according to the profit rules described above.
- He can reject the Seller's offer and quit the game (**"reject and quit"**). In this case, the game is over and both players receive a payoff of zero.
- He can reject the Seller's offer and make a counteroffer (**"reject and make counteroffer"**). If the Seller offered \$17 (\$23, respectively.) and the Buyer rejects this offer and makes a counteroffer, this counteroffer will automatically be \$23 (\$17, resp.). The game proceeds to the next round.

After the Buyer made his decision in Round 1, the game either ends (if he decided to "accept" or if he decided to "reject and quit"), or the game proceeds to Round 2 (if he decided to "reject and make counteroffer").

Round 2
If the game continues in Round 2, the Seller will be asked to respond to the Buyer's offer from the previous round. He has the following three options:

The Seller's options:
- He can accept the Buyer's offer ("accept"). In this case, the game is over and the profits of each player are calculated according to the profit rules described above.
- He can reject the Buyer's offer and quit the game ("reject and quit"). In this case, the game is over and both players receive a payoff of zero.
- He can reject the Buyer's offer and make a counteroffer ("reject and make counteroffer"). If the Buyer offered \$17 (\$23, resp.) in Round 1, and the Seller rejects this offer and makes a counteroffer, this counteroffer will automatically be \$23 (\$17, resp.).

After the Seller has made his decision in Round 2, the game either ends (if he decided to "accept" or if he decided to "reject and quit"), or the Buyer will be asked to respond to his offer (if the Seller decided to "reject and make counteroffer") . Again, like in Round 1, the Buyer can choose between one of the three options:
- accept
- reject and quit
- reject and make counteroffer

as described in "The Buyer's options" above. If the Buyer decides to reject and make a counteroffer, the game will proceed to Round 3. The rules in Round 3 are identical with those of Round 2, i.e. Round 3 starts again with the Seller's decision as described in "The Seller's options".

In each round, each player can choose whether to terminate or to continue the game. **The game continues until either an agreement is reached (one player accepts the other player's offer) or one player quits the game.** There is no limit on the number of rounds you and your partner can play.

The Payoffs

The payoff of a game depends on the round in which the agreement has been reached. If an agreement is reached in Round 1, the payoffs will be the full profits the players made, i.e.

Buyer's payoff = Buyer's valuation - accepted price offer
Seller's payoff = accepted price offer - Seller's cost

If an agreement is reached in a later round, the profits of both Buyer and Seller are multiplied by a factor of .8 with each round after Round 1. That is, if an agreement is reached in Round 2, each dollar profit is paid off only 80 cents. If an agreement is reached in Round 3, each dollar profit is paid off (.8)(.8) = .64 cents. In Round 4, a dollar profit is worth (.8)(.8)(.8) = .51 cents. And so on for further rounds.

Example: Suppose you reached an agreement in Round 4, where you made a profit of $10. Your payoff would then be (.8)(.8)(.8)($10) = (.51)($10) = $5.10. You would be paid off $5.10 in real money for this game if it is one of the two games selected at the end of the experiment. If you made a loss in one of these two games, we will subtract at most $2 from the $7 that you earned for showing up. All other losses are forgiven. Remember that you can always choose to quit and avoid losses.

Remember:

Each player will know only his/her own cost/valuation, but not their partner's. For each player, there is a 50 percent chance of having a high or low cost/valuation. Whether your own cost/valuation is high or low is completely independent of your partner's cost/valuation.

7.2 Instructions for Treatment BOO[22]

General Information

In this experiment you will face a decision problem involving two people. The decision problem will subsequently be denoted as "game", and the people participating in it will be denoted as "players". One of the two players in a game is always a "Seller" and the other one a "Buyer". They can bargain over a price for an object, but the Buyer can also search for another price offer by leaving the Seller. The bargaining and the search proceed via computer. No verbal communication is possible.

Participants in this experiment are divided into two groups, the group of Sellers and the group of Buyers. Whether you are a Seller or a Buyer will be determined in the beginning of the first game, and you will keep this role for the entire experiment.

You will play 20 games in this experiment. In each game, you will be randomly matched with another participant in this room. He/she will remain anonymous and will change from one game to another. It is possible that you encounter the same partner again. Your partner will only be

[22]Instructions for GOO are identical except for the random draw.

informed about your decision, but not about your name or your participation number, i.e., **your decision will be completely anonymous**. Each player will be informed about his/her own payoff in each game, but not about the partner's payoff.

After a game is finished, you will be randomly matched with another person to play a new game. **At the end of the experiment, two games will be drawn at random, and each participant will receive his/her payoffs from these two games in real money.**

The Game

In each of the 20 games, you can bargain over the price of a (fictitious) object, which you can buy if you are a Buyer, or sell if you are a Seller. The Buyer can also leave the Seller and search for another price. Each game consists of several rounds. You will keep the same partner for all rounds of a game. Once a new game starts, you will be matched with a different partner. **All participants receive the same information about the game.**

A game can either be in the **Bargaining Phase** or in the **Search Phase**. In the Bargaining Phase, the Seller and the Buyer bargain over the price for the object. In the Search Phase, the Buyer searches for other price offers, while the Seller has to wait. The Buyer can return to the Seller and continue bargaining, or accept an offer he found from search.

The Sellers
Each Seller has a certain cost of selling the object. At the beginning of a game, each Seller will be informed about his/her cost, which is determined by a random draw of the computer:

- There is a 50 % chance that a Seller has a **low cost of $**3.
- There is a 50 % chance that a Seller has a **high cost of $**22.

Only these two cost levels are possible. A Seller's cost remains the same in all rounds of a game. Once a new game starts, there is a new random draw with a 50-50 chance for each Seller of having a high or low cost.

The Seller's profit

- **if the game ends in the Bargaining Phase**
  If a Seller and a Buyer come to an agreement over the price, the Seller's profit is calculated in the following way:

  Seller's profit = accepted price offer - Seller's cost

  Thus, if the Seller and the Buyer agree on a price that is above the Seller's cost, the Seller will make a profit. If the price is below the Seller's cost, he will make a loss. If they don't agree on a price, the Seller's profit is zero.

- **if the game ends in the Search Phase**
  If the Buyer accepts a price he found in the search phase, **the Seller's profit is zero.**

The Buyers
Each Buyer has a certain valuation for the object. At the beginning of a game, each Buyer will be informed about his/her valuation, which is determined by a random draw of the computer:

- There is a 50 % chance that a Buyer has a **high valuation of $**37.
- There is a 50 % chance that a Buyer has a **low valuation of $**18.

Only these two valuations are possible. A Buyer's valuation remains the same in all rounds of a game. Once a new game starts, there is a new random draw with a 50-50 chance for each Buyer of having a high or low valuation.

The Buyer's valuation and the Seller's cost are randomly determined and independent from each other.

The Buyer's profit

- **if the game ends in the Bargaining Phase**
  If a Seller and a Buyer come to an agreement over the price, the Buyer's profit is calculated in the following way:

  Buyer's profit = Buyer's valuation - accepted price offer

  Thus, if they agree on a price that is below the Buyer's valuation, the Buyer will make a profit. If the price is above the Buyer's valuation, he will make a loss.

- **if the game ends in the Search Phase**
  If the Buyer accepts an offer he found in the search phase, his profit is

  Buyer's profit = Buyer's valuation - accepted offer from search

Bargaining and Searching

Round 1
A game always starts in the Bargaining Phase. In Round 1, the Seller starts by making an offer to the Buyer. **This offer can be either $17 or $23. No other offers are possible**. The Buyer will be informed about the Seller's decision and will then be asked to choose between one of the following three options:

The Buyer's options in the Bargaining Phase:

- He can accept the Seller's offer (**"accept"**). In this case, the game ends in the Bargaining Phase and the profits of each player are calculated according to the profit rules described above.
- He can reject the Seller's offer and start search (**"reject and start search"**). In this case, the Search Phase starts, which is described below.
- He can reject the Seller's offer and make a counteroffer (**"reject and make counteroffer"**). If the Seller offered $17 ($23, respectively) and the Buyer rejects this offer and makes a counteroffer, this counteroffer will automatically be $23 ($17, resp.). The game proceeds to the next round in the Bargaining Phase.

After the Buyer made his decision in Round 1, the game either ends (if he decided to "accept"), or the game proceeds to Round 2. **In Round 2, the game is either in the Search Phase** (if the Buyer decided to "reject and start search") **or in the Bargaining Phase** (if the Buyer decided to "reject and make counteroffer").

Continuing in the Bargaining Phase
If the game in the next round continues in the Bargaining Phase, the Seller will be asked to respond to the Buyer's offer from the previous round. He has the following three options:

The Seller's options:

- He can accept the Buyer's offer (**"accept"**). In this case, the game ends in the Bargaining Phase and the profits of each player are calculated according to the profit rules described above.
- He can reject the Buyer's offer and quit the game (**"reject and quit"**). In this case, the Seller receives a payoff of zero. The Buyer continues in the Search Phase and cannot return to the Seller anymore.
- He can reject the Buyer's offer and make a counteroffer (**"reject and make counteroffer"**). If the Buyer offered $17 ($23, resp.) in Round 1, and the Seller rejects this offer and makes a counteroffer, this counteroffer will automatically be $23 ($17, resp.).

After the Seller has made his decision in this round, the game either ends for the Seller (if he decided to "accept" or if he decided to "reject and quit"), or the Buyer will be asked to respond to his offer (if the Seller decided to "reject and make counteroffer"). Again, as in Round 1, the Buyer can choose between one of the three options:

- accept
- reject and start search
- reject and make counteroffer

as described in "The Buyer's options in the Bargaining Phase" above. If the Buyer decides to reject and start search, the game will proceed to the next round in the *Search Phase*. If the Buyer decides to reject and make a counteroffer, the game will proceed to the next round and will remain in the *Bargaining Phase*.

Continuing in the Search Phase

If the Buyer decided to "reject and start search" in any round, the Search Phase begins in the next round. **The Seller has to wait as long as the Buyer is searching.** The Buyer will receive a random number between 0 and 50, where all numbers are equally likely to be drawn. This will be the price offer he found from search in this round. Then he can choose between one of the following three options:

The Buyer's options in the Search Phase:

- He can accept the offer he found from search (**"accept offer from search"**). In this case, the game ends in the Search Phase and the profits are calculated as described above.
- He can reject the offer he found from search and continue search (**"reject and continue search"**). In this case, a new random number between 0 and 50 will be drawn in the next round for the Buyer, while the Seller has to wait.
- He can reject the offer he found from search and return to bargaining with the Seller (**"reject and return to bargaining"**). In this case, the Seller makes a new offer in the next round, which can be either \$17 or \$23. He can change his previous offer.

After the Buyer has made his decision, the game either ends (if he chose to "accept offer from search") or the game proceeds to the next round. As long as the Seller has not quit the game, the next round will be either in the Search Phase (if the Buyer chose to "reject and continue search") or in the Bargaining Phase (if the Buyer chose to "reject and return to Seller"). If the Seller has quit the game, the Buyer can only search. Then the game ends as soon as the Buyer accepts an offer he found from search.

The Payoffs

The payoff of a game depends on the round in which the agreement has been reached. If an agreement is reached in Round 1, the payoffs will be the full profits the players made. If an agreement is reached in a later round, the profits of both Buyer and Seller are multiplied by a factor of .8 with each round after Round 1. That is, if an agreement is reached in Round 2, each dollar profit is paid off only 80 cents. If an agreement is reached in Round 3, each dollar profit is paid off $(.8)(.8) = .64$ cents. In Round 4, a dollar profit is worth $(.8)(.8)(.8) = .51$ cents. And so on for further rounds.

Example 1: Suppose the game ended in the Bargaining Phase in Round 4, where you made a profit of \$10. Your payoff would then be $(.8)(.8)(.8)(\$10) = (.51)(\$10) = \$5.10$. You would be paid off \$5.10 in real money for this game if it is one of the two games selected at the end of the experiment. If you made a loss in one of these two games, we will subtract at most \$2 from the \$7 that you earned for showing up. All other losses are forgiven.

Example 2: Suppose the game ended in the Search Phase in Round 4, where the Buyer accepted an offer from search and made a profit of \$10. His payoff would then be $(.8)(.8)(.8)(\$10) = (.51)(\$10) = \$5.10$, and the Seller's payoff would be zero.

Remember:

Each player will know only his/her own cost/valuation, but not their partner's. For each player, there is a 50 percent chance of having a high or low cost/valuation. Whether your own cost/valuation is high or low is completely independent of your partner's cost/valuation.

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Francesco Feri and Anita Gantner

Bargaining or Searching for a Better Price? - An Experimental Study

Abstract

This experimental study investigates two bargaining games with twosided incomplete information between a seller and a buyer. In the first game with no outside options many subjects do not use the incomplete information to their advantage as predicted. We find that a model with adjusting priors better explains observed behavior. The second game gives the buyer the option to buy via search or return to bargaining. Here many buyers choose a bargaining agreement when a search outcome is predicted. For those who opt out, search outcomes are overall efficient and behavior is relatively close to the optimal search policy.

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